9.1 Circulatory Systems

The **circulatory system** is a transport system that moves substances around the body. It is described as a system of **blood vessels** with a **pump** (the heart) and **valves** to ensure one-way flow of blood.

Types of Circulation

Feature	**Single Circulation (e.g., Fish)**	**Double Circulation (e.g., Mammals)**
Pathway	Blood passes through the heart **once** per complete circuit of the body.	Blood passes through the heart **twice** per complete circuit of the body.
Circuits	One circuit: Heart → Gills → Body → Heart.	Two circuits: **Pulmonary** (Heart → Lungs → Heart) **Systemic** (Heart → Body → Heart)
Blood Pressure	Lower pressure after the gills.	Higher pressure to the body tissues.
Advantage of Double Circulation		Allows for **higher pressure** to be maintained in the systemic circulation, leading to a **faster rate of delivery** of oxygen and nutrients to the body tissues.

Monitoring Heart Activity

The activity of the heart may be monitored by:

- **ECG (Electrocardiogram):** Records the electrical activity of the heart.
- **Pulse Rate:** The number of heartbeats per minute, measured at an artery close to the skin.
- **Listening to Valve Sounds:** Using a stethoscope to detect the characteristic 'lub-dub' sounds of the valves closing.

Effect of Physical Activity on Heart Rate: Physical activity **increases** the rate of respiration in muscle cells, increasing the demand for oxygen and glucose and the need to remove carbon dioxide. The heart rate increases to:

1 Supply more **oxygen** to the muscles.
2 Supply more **glucose** to the muscles.
3 Remove more **carbon dioxide** from the muscles.

Coronary Heart Disease (CHD)

Coronary heart disease is caused by the blockage of the **coronary arteries** (the arteries that supply oxygen and nutrients to the heart muscle itself).

Risk Factors for CHD:

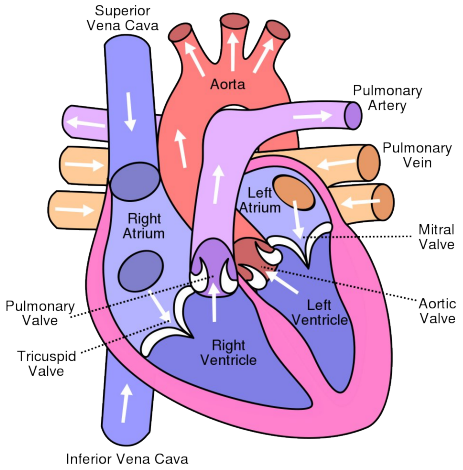
- **Diet:** High intake of saturated fat and cholesterol.
- **Lack of Exercise:** Leads to high blood pressure and obesity.
- **Stress:** Increases blood pressure.
- **Smoking:** Damages the lining of arteries and increases blood pressure.
- **Genetics:** Family history of heart disease.
- **Age and Sex:** Risk increases with age, and men are generally at higher risk than women.

Reducing Risk:

- **Diet:** Reducing intake of saturated fats and cholesterol; increasing fruit and vegetable intake.
- **Exercise:** Regular physical activity strengthens the heart and improves circulation.

9.2 Heart

The mammalian heart is a muscular pump that drives the double circulatory system.



Structure of the Mammalian Heart

The heart is divided into four chambers: two **atria** (upper chambers) and two **ventricles** (lower chambers).

Structure	Function
Muscular Wall	Contracts to pump blood. The **left ventricle** has the thickest wall as it pumps blood to the entire body (systemic circulation).
Septum	The wall that separates the right side (deoxygenated blood) from the left side (oxygenated blood), ensuring they do not mix.
Atria	Receive blood from the body (right atrium) or lungs (left atrium). Walls are thinner than ventricles as they only pump blood to the ventricles.
Ventricles	Pump blood out of the heart to the lungs (right ventricle) or the body (left ventricle).
Atrioventricular Valves	Prevent backflow from the ventricles to the atria (Tricuspid on the right, Bicuspid/Mitral on the left).
Semilunar Valves	Prevent backflow from the arteries (aorta and pulmonary artery) into the ventricles.
Coronary Arteries	Supply oxygenated blood and nutrients to the heart muscle cells.

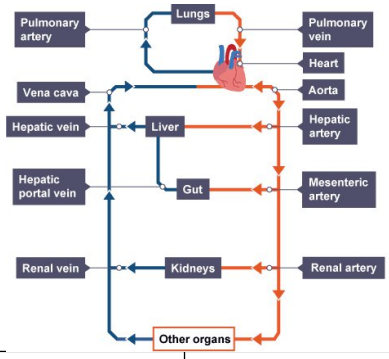
Functioning of the Heart (The Cardiac Cycle)

The heart functions in a cycle of contraction (systole) and relaxation (diastole):

4. **Atrial Contraction (Systole):** Atria contract, pushing blood into the ventricles through the open atrioventricular valves.
5. **Ventricular Contraction (Systole):** Ventricles contract. The atrioventricular valves close (producing the first heart sound, 'lub'), and blood is forced into the arteries through the open semilunar valves.
6. **Relaxation (Diastole):** The whole heart relaxes, allowing blood to flow into the atria. The semilunar valves close (producing the second heart sound, 'dub').

9.3 Blood Vessels

Blood is transported around the body in a closed system of blood vessels: arteries, veins, and capillaries.



Vessel Type	Wall Thickness	Lumen Diameter	Valves	Function
Artery	**Thick** and muscular (to withstand high pressure).	**Narrow** (maintains high pressure).	**None** (except semilunar valves at the heart).	Carries blood **away** from the heart.
Vein	**Thin** (as pressure is low).	**Wide** (offers less resistance to flow).	**Present** (to prevent backflow of blood).	Carries blood **towards** the heart.
Capillary	**One cell thick** (allows for easy diffusion).	**Very narrow** (blood cells pass in single file).	**None**.	Site of **exchange** of materials (gases, nutrients, waste) between blood and tissues.

Main Blood Vessels

Vessel	Location	Carries
Vena Cava	Heart	Deoxygenated blood from the body to the **right atrium**.
Aorta	Heart	Oxygenated blood from the **left ventricle** to the body.
Pulmonary Artery	Heart → Lungs	Deoxygenated blood from the **right ventricle** to the lungs.
Pulmonary Vein	Lungs → Heart	Oxygenated blood from the lungs to the **left atrium**.
Renal Artery	Aorta → Kidney	Blood to the kidney (high in urea).
Renal Vein	Kidney → Vena Cava	Blood from the kidney (low in urea).
Hepatic Artery	Aorta → Liver	Oxygenated blood to the liver.
Hepatic Vein	Liver → Vena Cava	Blood from the liver.
Hepatic Portal Vein	Intestine → Liver	Blood rich in digested food from the small intestine to the liver.

9.4 Blood

Blood is composed of four main components: plasma, red blood cells, white blood cells, and platelets.

Components and Functions of Blood

Component	Description	Function
Plasma	Pale yellow liquid, mostly water.	**Transport** of blood cells, **ions**, digested food (glucose, amino acids), **urea**, **hormones**, and **carbon dioxide** (as hydrogencarbonate ions).
Red Blood Cells	Biconcave discs, no nucleus, contain **haemoglobin**.	**Transport oxygen** from the lungs to the tissues via haemoglobin (binds to oxygen).
White Blood Cells	Larger than red cells, have a nucleus.	**Immunity** and defence against pathogens. Two main types: **Phagocytes** and **Lymphocytes**.
↳	**Phagocytes**	Carry out **phagocytosis** (engulfing and digesting pathogens).
↳	**Lymphocytes**	Produce **antibodies** to destroy pathogens.
Platelets	Small fragments of cells, no nucleus.	**Blood clotting** to prevent blood loss and the entry of pathogens.

Blood Clotting

Blood clotting is a vital process that stops blood loss and prevents the entry of pathogens into the body.

Process of Clotting:

7 Damage to the blood vessel exposes tissue, causing platelets to stick to the damaged area.
8 A series of reactions converts the soluble plasma protein **fibrinogen** into insoluble threads of **fibrin**.
9 The fibrin threads form a **mesh** that traps red blood cells and platelets, forming a clot.